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( Reaffirmed 2002 )

# *Indian Standard*

# SPECIFICATION FOR ELECTRICAL INSTALLATIONS IN SHIPS

## PART 3 EQUIPMENT

### Section 1 Generators and Motors

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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**IS : 10242 ( Part 3/Sec 1 ) - 1983**

# *Indian Standard*

# SPECIFICATION FOR ELECTRICAL INSTALLATIONS IN SHIPS

## PART 3 EQUIPMENT

### Section 1 Generators and Motors

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# *Indian Standard*

# SPECIFICATION FOR ELECTRICAL INSTALLATIONS IN SHIPS

## PART 3 EQUIPMENT

### Section 1 Generators and Motors

## 0. FOREWORD

**0.1** This Indian Standard ( Part 3/Sec 1 ) was adopted by the Indian Standards Institution on 6 July 1983, after the draft finalized by Electrical Equipment in Ships Sectional Committee had been approved by the Electrotechnical Division Council.

**0.2** This standard ( Part 3/Sec 1 ) is one among the series of the Indian Standards on electrical installations in ships. This series will have the following parts:

Part I General,
Part II System design,
Part III Equipment,
Part IV Installation and test of completed installation, and
Part V Special features.

**0.3** In preparing this standard assistance has been taken from the IEC Publication 92 Part 301 ( 1980 ): 'Equipment — Generators and Motors', issued by the International Electrotechnical Commission.

**0.4** This part of the standard shall be read in conjunction with the other parts mentioned in **0.2**.

**0.5** For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*Rules for rounding off numerical values ( *revised* ).

## 1. SCOPE

**1.1** This standard ( Part 3/Sec 1 ) applies to all rotating electrical machines rated at 750 W or more for installation on board ships. It also applies to excitation machines and includes relevant requirements for prime-movers driving generators.

**1.1.1** Requirements particular to propulsion machines are not covered in this standard.

## 2. GENERAL REQUIREMENTS

**2.1** All electrical machines shall comply with the requirements of all relevant Indian Standards on rotating machines and also with the additional requirements included in this standard.

## 3. PERFORMANCE

**3.1 Temperature Rise** — The limits of temperature rise shall be in accordance with Table 1.

**3.2 Unbalanced Load on Three-Wire DC Generators** — Unless otherwise specified, all dc generators shall be designed for a current unbalance of 25 percent.

## 4. VOLTAGE REGULATION OF GENERATORS

**4.1 DC Generators** — The inherent voltage regulation of ship's service dc generators shall be designed in relation to the speed regulation and governing of the prime-movers as follows.

**4.1.1** *Shunt or Stablized Shunt-Wound Generators* — Shunt or stablized shunt-wound generators rated at 50 kW and above, shall comply with the following requirements:

a) When the voltage has been set at full-load to its rated value, the removal of the load shall not cause a permanent increase of the voltage greater than 15 percent of the rated voltage.

b) When the voltage has been set either at full-load or at no-load, the voltage obtained at any value of the load shall not exceed the no-load voltage.

**4.1.2** *Compound-Wound Generators* — Compound-wound generators rated at 50 kW and above shall be so designed in relation to the governing characteristics of the prime-mover, that with the generator at full-load operating temperature and starting at 20 percent load with voltage within 1·5 percent rated voltage, it gives at full-load a voltage within 1·5 percent of rated voltage.

## TABLE 1 LIMITS OF TEMPERATURE RISE OF AIR-COOLED MACHINES BASED ON AN AMBIENT TEMPERATURE OF 50°C

( *Clause* 3.1 )

| Sl No. | Part of Machine | Class of Insulation | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A Method | | | E Method | | | B Method | | | F Method | | | H Method | | |
| | | Therm °C | Res °C | E.T.D. °C | Therm °C | Res °C | E.T.D. °C | Therm °C | Res °C | E.T.D. °C | Therm °C | Res °C | E.T.D. °C | Therm °C | Res °C | E.T.D. °C |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
| 1. | AC windings of machines having output of 5 000 kW ( or kVA ) or more, or having a core length of one metre or more<br>Note — The E. T. D. method may be used in machines having outputs less than 5 000 kW ( or kVA ) or having a core length less than one metre, but the limits of temperature rise given in this item shall apply | — | 50 | 50 | — | 60 | 60 | — | 70 | 70 | — | 90 | 90 | — | 115 | 115 |
| 2 | a) AC windings of machines having outputs less than 5 000 kW (or kWA) or having a core length less than one metre<br>b) Field windings of ac and dc machines having excitation other than those in Sl No. 3 & 4<br>c) Windings of armatures having commutators | 40 | 50 | — | 55 | 65 | — | 60 | 70 | — | 75 | 90 | — | 95 | 115 | — |
| 3. | Field windings of turbine-type machines having dc excitation | — | — | — | — | — | — | — | 80 | — | — | 100 | — | — | — | — |
| 4. | a) Low-resistance field windings of more than one layer, and compensating windings | 50 | 50 | — | 65 | 65 | — | 70 | 70 | — | 90 | 90 | — | 115 | 115 | — |
| | b) Single-layer windings with exposed bare or varnished metal surface* | 55 | 55 | — | 70 | 70 | — | 80 | 80 | — | 100 | 100 | — | 125 | 125 | — |
| 5. | Permanently short-circuited insulated windings | 50 | — | — | 55 | — | — | 70 | — | — | 90 | — | — | 115 | — | — |
| 6. | Permanently short-circuited uninsulated windings | The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts | | | | | | | | | | | | | | |
| 7. | Magnetic core and other parts not in contact with windings | | | | | | | | | | | | | | | |
| 8. | Magnetic core and other parts in contact with windings | 50 | — | — | 65 | — | — | 70 | — | — | 90 | — | — | 115 | — | — |
| 9. | Commutators and slip-ring† open or enclosed | 50 | — | — | 60 | — | — | 70 | — | — | 80 | — | — | 90‡ | — | — |

( *Continued* )

**TABLE 1 LIMITS OF TEMPERATURE RISE OF AIR-COOLED MACHINES BASED ON AN AMBIENT TEMPERATURE OF 50°C** — *Contd*

*Also includes multiple-layer field windings provided that the underlayers are each in contact with the circulating coolant.

†The temperature-rises ia Sl No. 9 are permissible provided that insulation appropriate to the temperature-rise is used, except when the commutator or slip-ring is adjacent to windings in which case of temperature-rise shall not exceed that for the winding insulation class. The values of temperature-rises given apply only to measurements made by bulb thermometers.

‡Special precautions may be necessary in using temperature rises of 90°C in the choice of brush grades.

NOTE 1 — Classes F and H shall only be used after agreement between the manufacturer and the purchaser.

NOTE 2 — Embedded temperature detector (E.T.D.) method — Embedded temperature detectors are resistance thermometers or thermocouples built into the machine during construction at points which are inaccessible after the machine is completed.

Methods of temperature measurement by embedded temperature detectors — When the E.T.D. method is used, at least six detectors, suitably distributed round the stator, shall be built into the machine. All reasonable efforts, consistent with safety, shall be made to place the detectors at the various points at which the highest temperatures are likely to occur, in such a manner, that they are effectively protected from contact with the coolant.

Two coil-sides per slot—When the winding has two coil-wides per slot, each detector shall be located between insulated coil-sides within the slot.

More than two coil-sides per slot — When the winding has more than two coil-sides per slot, each detector shall be located between insulated coil-sides in positions at which the highest temperatures are likely to occur.

NOTE 3 — If air-to-water heat exchangers are used, the temperature-rise will be specified with respect to the temperature of the cooling water at the inlet of the cooler, In this case, the temperature-rises given in the table shall be increased by 20°C, but only if the specified inlet water temperature does not exceed 30°C. When commutators of these machines are not in the enclosed air circuit cooled by the water cooler, but are cooled by the ambient cooling air, the permissible temperature-rise above the ambient cooling air shall be the same as for ventilated machines.

NOTE 4 — Where a machine is designed to operate with a coolant at a temperature more or less than an ambient temperature of 50°C, the pesmissible temperature rises may be reduced or increased in accordance with the given ambient temperature. The permissible temperature rises shall be taken to the nearest whole Celsius degree.

The average of ascending and descending voltage regulation curves between 20 percent load and full-load shall not vary more than 3 percent from rated voltage.

**4.1.3** *Other Types of Generators* — Generators required to have characteristics not covered by **4.1.1** or **4.1.2** shall be subject to special consideration.

**4.1.4** *Automatic Voltage Regulation for DC Service Generators* — Service generators which are of the shunt type shall be provided with automatic voltage regulators. Automatic voltage regulators shall also be provided for all service generators driven by variable speed engines used also for propulsion purposes, whether these generators are of the shunt, stabilized shunt or compound-wound type.

**4.2 AC Generators** — The excitation system of ac generators rated 50 kVA and above, provided in accordance with **7.4** shall also comply with the following requirements.

**4.2.1** *Steady Conditions ( Except During Paralleling )* — Each ac generator for ship's service driven by its prime-mover having governor characteristics complying with 10·3 shall be provided with an excitation system capable of maintaining the voltage under steady conditions within plus or minus 2·5 percent of the rated voltage for all loads between zero and rated load at rated power factor. These limits may be increased to plus or minus 3·5 percent for emergency sets ( *see* **4.2.4** ).

NOTE — Attention is drawn to the possibility that under certain operating conditions the power factor may be less than the rated value, and this can affect the voltage regulation.

**4.2.2** *Transient Conditions* — When the generator is driven at rated speed giving its rated voltage, and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage shall not fall below 85 percent nor exceed 120 percent of the rated voltage.

The voltage of the generator shall then be restored to within plus or minus 3 percent of the rated voltage for the main generator sets in not more than 1·5 seconds. For emergency sets, these values may be increased to plus or minus 4 percent in not more than 5 seconds respectively ( *see* **4.2.4** ).

In the sbsence of precise information concerning the maximum values of the sudden loads, the following conditions shall be assumed: 60 percent of rated current with a power factor of between 0·4 lagging and zero to be thrown on with the generator running at no-load, and then withdrawn after steady-state conditions have been reached.

NOTE 1 — For the purpose of verifying the above, the generator under test may be driven by a suitable electric motor at practically constant speed.

NOTE 2 — To achieve satisfactory performance on board ship, the governor of the prime-mover shall restore the speed to a steady state within the limits specified in **10.3** in not more than 3 seconds.

NOTE 3 — The maximum recovery time of 1·5 seconds may be insufficient on installations with large and frequent load variations, for example, winch and crane operation. A lesser recovery time may be agreed upon by the manufacturer and the purchaser.

**4.2.3** *Steady Short-Circuit Conditions* — Under steady short-circuit conditions the generator with its excitation system shall be capable of maintaining a current of at least three times its rated value for a duration of up to 2 seconds, unless protection selectivity requirements exist which allow a shorter duration and provided that, in any case, the safety of the installation is assured.

**4.2.4** *Emergency Generators* — Emergency sets which are required to meet the same general requirements as in **4.2.2** need only maintain the steady-state voltage within 3·5 percent and during transient conditions to recover its voltage within 4 percent in not more than 5 seconds.

### 4.3 Generators for Special Purposes

**4.3.1** *DC Generators* — DC generators for special purposes, together with their excitation system, shall have such voltage characteristics as are required.

**4.3.2** *AC Generators* — AC generators for special purposes and ship's service ac generators smaller than 50 kVA together with their excitation system shall have voltage characteristics agreed between the manufacturer and the purchaser.

## 5. PARALLEL OPERATION OF SHIP'S SERVICE GENERATORS — DC GENERATORS

**5.1 Stability** — DC generators which are required to run in parallel shall be stable in operation at all loads from no-load to full-load.

**5.2 Load Sharing** — The design of dc generators and their connections shall be such that, when they operate in parallel, the individual load on each machine does not normally differ from the theoretical load ( proportional to rating ) by an amount greater than 12 percent of the rated full load of the largest machine or 25 percent of the rating of the individual machine in question. This requirement applies when the combined load on the sets is varied between 20 percent and 100 percent of the combined ratings. Such a load sharing shall not result in overloading the smaller set.

**5.3 Voltage Drop** — For each generator of a group required to run in parallel, the voltage drop across the series fields and its connection to the switchboard ( which may incorporate a resistor ) shall be approximately equal.

## 6. PARALLEL OPERATION OF SHIP'S SERVICE GENERATORS — AC GENERATORS

**6.1 Reactive Load Sharing** — When ac generators are operated in parallel, the reactive loads of the individual generating sets shall not differ from their proportionate share of the total reactive load within the range of 20 to 100 percent by more than 10 percent of the rated reactive output of the largest machine, or 25 percent of the smallest machine where this value is less than the former.

NOTE — The alternator design should incorporate sufficient damping in the rotor circuits to avoid power oscillation and instability when running in parallel.

**6.2 Load Sharing** — For ac generating sets operating in parallel, the governing characteristics of the prime-movers shall be such that within the limits of 20 percent and 100 percent total load, the load on any generating set does not normally differ from its proportionate share of the total load by more than 15 percent of the rated output of the larget machine or 25 percent of the rating of the individual machine in question.

The facilities for adjusting the governor at normal frequency shall be sufficiently fine to permit a minimum adjustment of load on engine not exceeding 5 percent of rated load ( *see also* Note 2 under **4.2.2** ).

NOTE — It is assumed that the speed of the prime-mover decreases with the application of the load and increases with its removal, permanent variation being such that the speed does not at any load vary from the straight line joining rated-load and no-load speed by more than one-fifth of the maximum permanent speed variation involved.

**6.3 Flywheel Effect for AC Generating Sets** — For ac generators operating in parallel, the combined flywheel effect of the flywheel and alternator shall be such that the angular deviation in either direction from the position of uniform rotation does not at any time exceed 3·5 electrical degrees, in addition to complying with the limt of cyclic irregularity given in **11.**

The engine manufacturer shall inform the supplier of the alternator as to the total flywheel effect which he considers should be provided to ensure that the maximum calculated angular deviation of 3·5 electrical degrees is not exceeded.

The engine manufacturer shall also state the frequencies of such engine disturbing forces as are of significant magnitude and the supplier of the alternator shall then specify to the engine manufacturer what additional flywheel effect, if any, is necessary for the avoidance of the effects of electoro-mechanical resonance ( due to the vibration of the generator ).

The generator maunfacturer shall provide all necessary information to the engine manufacturer who will be responsible for checking the whole system for critical speeds and for calculating the torsional rigidity and torsional strength of the complete shaft system. The engine manufacturer shall state what reasonable changes, if any, in the generator shafting are necessary to avoid the occurence of excessive stresses and such changes shall be undertaken by the generator manufacturer.

NOTE 1 — The angular deviation specified is that calculated, on the assumption that the torque of the alternator, that is, the torque opposite the notion of the engine, is uniform throughout the engine cycle.

NOTE 2 — The angular deviation specified applies to alternators on ordinary regulation. Alternators designed for special regulation may require still closer uniformity of rotation.

NOTE 3 — Avoidance of the effects of resonance means that the natural frequency of oscillation of the alternator with its flywheel, when connected to the electrical system with which it is to work in parallel, shall not approach the frequency of any engine impulses of significant magnitude.

## 7. CONTROL AND EXCITATION OF GENERATORS

**7.1 Field Regulation of DC Generators** — Means shall be provided at the switchboard to enable the voltage of each generator to be adjusted separately. The equipment provided shall be capable of adjusting the voltage of the dc generator to within 0·5 percent of the rated voltage for machines above 100 kW and 1 percent of the rated voltage for smaller machines, at all loads between no-load and full-load, with the dc generator coupled to its prime-mover at any permissible temperature within the working range. The regulator shall be capable of reducing the no-load voltage to 10 percent below the rated voltage with the generator cold.

**7.2 Polarity of Series Windings** — The series windings of each two-wire generator shall be connected to the negative terminal of each machine.

**7.3 Equalizer Connections** — Each equalizer connection shall have a cross-sectional area not less than half of the negative connection from the generator to the switchboard.

**7.4 Excitation of AC Generators** — The components of the excitation system, including automatic voltage regulator, if used, shall be of a type suitable for shipboard conditions and be capable of operating under all specified conditions of steady and transient load, including short-circuit, as stated in **4.2.1**, **4.2.2** and **4.2.3**.

When it is intended that two or more generators will be operated in parallel, means shall be provided to divide the reactive power properly between the generators ( *see* **6.1** ).

NOTE — Attention is drawn to the desirability of assuring that the failure of the excitation system ( including automatic voltage regulator if used ) shall not cause damage to the installation.

### 7.5 Overload Withstanding Capabilities

**7.5.0** Machines are to withstand, on test, without injury, the following momentary overloads.

**7.5.1** *Generators* — An excess current of 50 percent for 15 seconds after attaining the temperature rise corresponding to rated load, the terminal voltage being maintained as near the rated value as possible. The foregoing does not apply to the overload torque capacity of the prime-mover.

**7.5.2** *Motors* — At rated speed or, in the case of a range of speeds, at the highest and lowest speeds, under gradual increase of torque, the appropriate excess torque given below. Synchronous motors and synchronous induction motors are required to withstand the excess torque without falling out of synchronism and without adjustment of the excitation circuit preset in the value corresponding to rated load.

| | |
|---|---|
| DC motor | 50 percent for 15 seconds |
| Polyphase ac synchronous motors | 50 percent for 15 seconds |
| Polyphase ac synchronous induction motors | 35 percent for 15 seconds |
| Polyphase ac induction motors | 60 percent for 15 seconds |

**7.5.3** *Propulsion Machines* — The overload tests for propulsion machines will be specially considered for each installation.

## 8. MECHANICAL FEATURE ( GENERATORS AND MOTORS )

**8.1 Entry of Water** — Where water cooling is used, the cooler shall be so arranged as to avoid entry of water into the machine, whether by leakage or condensation in the heat exchanger.

**8.2 Accumulation of Moisture and Condensation** — Consideration shall be given to provide effective means to prevent accumulation of moisture and condensation within the machines especially when they are idle for appreciable periods, for example, by means of space heaters.

**8.3 Balance** — Machines shall be so constructed that, when running at any and every working speed all revolving parts are well balanced.

**8.4 Shaft Currents** — Measures should be taken to minimise the circulation of current between the shaft and the bearings to such an extent that they cannot damage the bearing of machine itself or to other machinery to which it is connected.

**8.5 Terminals** — Suitable terminals, clearly marked, shall be provided in an accessible position, convenient for external connections. The terminals shall be effectively secured and shall be so spaced and/or shielded that they cannot accidentally be earthed, short-circuited or touched.

**8.6 Welding of Shafts** — Where welding is applied to shafts for securing armature arms or spiders. Stress-relieving shall be carried out after welding.

**8.7 Axial Movement** — Adequate measures shall be adopted by prevention of axial movement of fixtures on shafts under all service conditions.

**8.8 Over Speed** — Rotating machines shall be capable of withstanding 1·2 times the rating maximum speed for 2 minutes.

## 9. LUBRICATION ( GENERATORS AND MOTORS )

**9.1** Generators and motors shall have efficient and continuous lubrication at all running speeds and all normal working bearing temperatures, with the inclinations from normal specified in Part I of this standard.

**9.2** Means shall be provided to prevent the lubricant from creeping along the shaft or otherwise gaining access to the insulation of the machine or to any live part thereof.

**9.3** Each oil-lubricated bearing shall be provided with a suitable overflow, which, while permitting efficient lubrication when the machine is running prevents the bearing from containing excess of oil.

**9.4** Where ring lubrication is employed, the rings shall be so constrained that they cannot leave the shaft.

**9.5** Each self-lubricated sleeve bearing shall be fitted with an inspection lid and means for visual indication of oil level or use of an oil-gauge.

This requirement does not apply to machines under 100 kW ( dc ) or 100 kVA ( ac ).

## 10. PRIME-MOVERS

**10.1 General** — Prime-movers driving generators intended for supplying power to essential services shall have a rating and overload capability comparable with the rating and the specified overload capability of the driven generators.

**10.2 Turbine-Driven DC Generating Sets in Parallel** — Where a turbine-driven direct-current generator is arranged to run in parallel with other generators, a switch shall be fitted on each turbine emergency governor for the purpose of opening the generator circuit-breaker when the emergency governor functions.

The contacts of the overspeed switch shall be normally closed.

**10.3 Governing Characteristics** — Governors on prime-movers shall be such that they will automatically maintain the speed within a momentary variation of 10 percent and a permanent variation not exceeding 5 percent when rated load is suddenly thrown off and when 50 percent load is suddenly thrown on followed after short instant by the remaining 50 percent load, unless other sudden load changes are specified.

Each prime-mover shall be fitted with an emergency overspeed device which will operate at a speed not more than 15 percent above rated speed and has provision for tripping by hand.

When the driven generators are required to operate in parallel, the gevernor characteristics shall comply with the requirements of **5.2** and **6.2**.

**10.4 Flywheel Effect** — The flywheel effect provided shall comply with the requirements of **6.3**.

## 11. CYCLIC IRREGULARITY

**11.0** The maximum permissible cyclic irregularity in a reciprocating engine throughout one engine cycle shall conform to the following.

**11.1** For an engine having one or two cylinders, the cyclic irregularity shall not be worse than 1/75 unless a closer limit is specified.

**11.2** For an engine of more than two cylinders, the cyclic irregularity shall not be worse than the values given in the following Table 2.

## 12. LUBRICATION ( PRIME-MOVERS )

**12.1** Prime-movers shall be efficiently and continuously lubricated at all running speeds and at all working oil temperatures without the spilling of oil with the ship at the inclination from normal speed as specified in Part 1/Sec 1 of this standard.

**12.2** Turbine-driven generating sets dependent of forced lubrication shall be arranged to shut down automatically on failure of lubrication and effective lubrication provided to prevent damage to the bearings during running down.

### TABLE 2 LIMITS OF CYCLIC IRREGULARITY

( *Clause* 11.2 )

| NUMBER OF ENGINE IMPULSES PER SECOND ( $f$ ) | CYCLIC IRREGULARITY TO BE NOT WORSE THAN |
|---|---|
| Up to 4 | 1/150 |
| 6 | 1/220 |
| 8 to 20 | $\frac{1}{\frac{2000}{f}-f}$ |
| Above 20 | 1/75 |

NOTE — Cyclic irregularity is defined as the ratio of the maximum variation in angular velocity at the flywheel during one engine cycle to the mean angular velocity when the engine is running at any load up to and including rated load and at rated speed. This is conveniently expressed as follows:

$$\frac{\text{Max speed} - \text{Min speed}}{\text{Mean speed}}$$

## 13. RUNNING SPEED

**13.1** The normal speed of a combined generating set shall not be in the vicinity of a critical speed.

## 14. TESTING

**14.1** Sufficient tests shall be made in accordance with IS : 4722-1968* to ensure that the machine is in accordance with these recommendations.

**14.1.1** The dielectric test voltage and temperature rise of various machine parts shall be in accordance with Tables 1 and 3.

## 15. DEGREE OF PROTECTION BY ENCLOSURES

**15.1** The degree of protection by enclosures shall be in accordance with the relevant location as specified in **28** of IS : 10242 ( Part 2/Sec 1 )-1982†.

## 16. RATING PLATES

**16.1** All machines shall have a rating plane marked with the appropriate items as required by the following list and in addition with the specification to which the machine conforms, but these items need not all be on the same plate:

a) The manufacturer's name;

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*Specification for rotating electrical machines.

†Specification for electrical installations in ships: Part 2 System design, Section 1 General.

b) The manufacturer's serial number, or identification mark, and year of manufacture;

c) The type of machine: motor or generator; shunt, series, compound, cage, etc;

d) The class of rating according to the relevant Indian Standards; the duration and sequence may be indicated by a qualifying term;

e) The rated output;

f) The rated voltage;

g) The rated current;

h) Type of current ( dc ........... or ac ∼ );

j) For ac machines, the rated frequency and number of phases;

k) The rated speed or speed range;

m) The permissible overspeed, if applicable ( for example, turbine driven generators );

n) The class of insulation or the permissible temperature rise;

p) The number and year of the specification ( for example, IS...... )

q) For ac machines, the widing connections designated by the appropriate symboles from the relevant Indian Standard;

r) For ac machines, the power factor;

s) For synchronous machines for dc machines with separate excitation, current and voltage;

t) For wound-rotor induction machines, the open-circuit voltage between slip-rings and the slip-ring current for rated conditions; and

u) The ambient temperature.

NOTE — The above items are numbered for convenient reference, but the order in which they appear on the rating plate is not standardized.

**16.1.1** The machine may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution ( Certification Marks ) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

## TABLE 3 DIELECTRIC TESTS

( *Clause* 14.1.1 )

| SL No. | MACHINE OR PART | TEST VOLTAGE (RMS) |
|---|---|---|
| 1. | Insulated windings of rotating machines of size less than 1 kW or 1 kVA, and of rated voltage less than 100 V with the exception of those in Sl No. 4 to 8. | 500 V + twice the rated voltage |
| 2. | Insulated windings of rotating machines of size less than 10 000 kW or 10 000 kVA with the exception of those in Sl No. 1 and Sl No. 4 to 8 ( *see* Note 2 ) | 1 000 V + twice the rated voltage with a minimum of 1 500 V ( *see* Note 1 ) |
| 3. | Insulated Windings of rotating machines of size 10 000 kW or kVA or more with the exception of those in Sl No. 4 to 8 ( *see* Note 2 ) | |
| | Rated voltage ( *see* Note 1) : | |
| | — *U* up to 2 000 V | 1 000 V + 2 *U* |
| | — *U* above 2 000 V to 6 000 V | 2·5 times *U* |
| | — *U* above 6 000 V to 17 000 V | 3 000 V + 2 *U* |
| | — *U* above 17 000 V | Subject to special agreement |
| 4. | Separately-excited field windings of dc machines | 1 000 V + twice the maximum rated circuit voltage with a minimum of 1 500 V |
| 5. | Field windings of synchronous generators, synchronous motors and synchronous condensers | |
| | a) Field windings of synchronous generators | Ten times the rated excitation voltage with a minimum of 1 500 V and a maximum of 3 500 V |
| | b) When a machine is intended to be started with the field winding short-circuited or connected across a resistance of value less than ten times the resistance of the winding | Ten times the rated excitation voltage with a minimum of 1 500 V and a maximum of 3 500 V |
| | c) When the machine is intended to be started either with the field winding connected across a resistance of value equal to, or more than, ten times the resistance of the winding, or with the field windings on open circuit with or without a field-dividing switch | 1 000 V + twice the maximum value of the rms voltage, which can occur under the specified starting conditions, between the terminals of the field winding, or in the case of a sectionalized field winding, between the terminals of any section, with a minimum of 1 500 V ( *see* Note 3) |

( *Continued* )

## TABLE 3 DIELECTRIC TESTS — *Contd*

| Sl No. | Machine or Part | Test Voltage (RMS) |
|---|---|---|
| 6. | Secondary ( usually rotor ) windings of induction motors or synchronous induction motors if not permanently short-circuited ( for example, if intended for rheostatic starting ) | |
| | a) For non-reversing motors or motors reversible from standstill only | 1 000 V + twice the open-circuit standstill voltage as measured between slip-rings or secondary terminals with rated voltage apped to the primary windings |
| | b) For motors to be reversed or braked by reversing the primary supply while the motor is running | 1 000 V + four times the open-circuit standstill secondary voltage as defined in Sl No. 6 (a) |
| 7. | Exciters ( except as below ) | As for the windings to which they are connected |
| | *Exception* 1 — Exciters of synchronous motors ( including synchronous induction motors ) if connected to earth or disconnected from the field windings during starting | 1 000 V + twice the rated exciter voltage, with a minimum of 1 500 V |
| | *Exception* 2 — Separately excited field windings of exciters ( *see* Sl No. 4 ) | |
| 8. | Assembled group of machines and apparatus | A repetition of the tests in Sl No. 1 to 7 above should be avoided if possible, but if a test on an assembled group of several pieces of new apparatus, each one of which has previously passed its high-voltage test, is made, the test voltage to be applied to such assembled group shall be 80 percent of the lowest test voltage appropriate for any part of the group ( *see* Note 4 ) |

Note 1 — For two-phase windings having one terminal in common, the rated voltage for the purpose of calculating the test voltage shall be taken as 1·4 times the voltage of each separate phase.

Note 2 — High-voltage tests on machines having graded insulation shall be the subject of special agreement.

Note 3 — The voltage occurring between the terminals of the field windings, or sections thereof, under the specified starting conditions may be measured at any convenient reduced supply voltage, and the voltage so measured shall be increased in the ratio of the specified starting supply voltage to the test supply voltage.

Note 4 — For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

# INTERNATIONAL SYSTEM OF UNITS ( SI UNITS )

## Base Units

| QUANTITY | UNIT | SYMBOL |
|---|---|---|
| Length | metre | m |
| Mass | kilogram | kg |
| Time | second | s |
| Electric current | ampere | A |
| Thermodynamic temperature | kelvin | K |
| Luminous intensity | candela | cd |
| Amount of substance | mole | mol |

## Supplementary Units

| QUANTITY | UNIT | SYMBOL |
|---|---|---|
| Plane angle | radian | rad |
| Solid angle | steradian | sr |

## Derived Units

| QUANTITY | UNIT | SYMBOL | DEFINITION |
|---|---|---|---|
| Force | newton | N | 1 N = 1 kg.m/$s^2$ |
| Energy | joule | J | 1 J = 1 N.m |
| Power | watt | W | 1 W = 1 J/s |
| Flux | weber | Wb | 1 Wb = 1 V.s |
| Flux density | tesla | T | 1 T = 1 Wb/$m^2$ |
| Frequency | hertz | Hz | 1 Hz = 1 c/s ($s^{-1}$) |
| Electric conductance | siemens | S | 1 S = 1 A/V |
| Electromotive force | volt | V | 1 V = 1 W/A |
| Pressure, stress | pascal | Pa | 1 Pa = 1 N/$m^2$ |